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(54) APPARATUS FOR DECODING AND DISPLAY OF DIGITAL INFORMATION

(71) I, THEODORE PARASKEVAKOS, a Greek citizen of 61 Stadiou Str.—Athens (141) Greece, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus for decoding and display of digital information.

One aspect of the invention consists in apparatus for decoding a plurality of signal pulse trains, each pulse train representing one digit or other character of information data, and for displaying the data, the apparatus comprising input means for accepting the signal pulse trains, digit separation detector means connected to the input means for discriminating between individual pulse trains and for generating a digit separation signal in response thereto, starting detector means connected to the input means for detecting a pulse train different from said individual pulse trains and for providing a start signal in response thereto, decoding and display means connected to the digit separation detector means and to the starting detector means for decoding each of said individual pulse trains received and displaying a corresponding character, after the said different pulse train has been detected.

Another aspect of the invention consists in apparatus for decoding a plurality of signal pulse trains, each pulse train representing one digit of a number and for displaying the number, the apparatus comprising digit detector means for discriminating between individual pulse trains and for generating a digit separation signal in response thereto, starting detector means for detecting a pulse train different from said individual pulse trains and for providing a start signal in response thereto, shift register means comprising a plurality of interconnected bistable stages, the shift register means being connected to the digit detector means and to the starting detector means to cause successive ones of the bistable stages to change state in response to successive digit separation signals occurring after the start signal, a plurality of gate means each having one input connected to one of the bistable stages and another input connected for receiving the signal pulse trains whereby any given gate means is enabled to pass the next occurring pulse train in response to its associated bistable stage changing state, and counting and display means connected to each gate means for decoding and displaying the particular pulse train passed by its associated gate means whereby successively to decode and display each successive digit of the number.

The embodiments described below relate to apparatus for receiving and decoding a series of signal pulse trains and for displaying a number composed of a series of digits represented by the series of pulse trains.

The embodiments are suitable, for example, for receiving pulse trains such as those generated by appropriate embodiments of the transmitting apparatus disclosed in my co-pending Patent application No. 23923/71 (Serial No. 1,362,412).

Such transmitting apparatus may be located at a central telephone exchange and adapted to send a series of signal pulses to a called telephone representing the calling telephone number. Each individual pulse train can represent an individual digit of the telephone number. The actual number of such pulse trains depends on the number of digits of the telephone number included in an area code. Extra digits may be transmitted to convey additional information concerning the calling number, such as identification as a pay phone booth, and so on. In addition another pulse train different from said individual pulse trains (and thus, within the context of any one embodiment having uniquely identifiable characteristics) has to be used in relation to embodiments of the present invention to signify the beginning of a complete series of signal pulse trains.

In each case, the number of pulses in each

train is usually representative of the corresponding digit value. For instance, the telephone number 312—217—6864 would usually be transmitted (disregarding the uniquely identifiable train, and the added information trains) as a series of ten pulse trains with the first pulse train consisting of three pulses, the second having one pulse, the third having two pulses, etc. Each pulse train is separated by a dead time or quiescent period exceeding that which occurs between individual pulses in any single train and the uniquely identifiable pulse train is for example, comprised of 12 pulses to make it different from any of the other pulse trains. Of course, other specific numerical codes could be used for the digit and uniquely identifiable pulse trains as will become apparent and as will be explained in more detail with one of the preferred embodiments discussed below. It should also be understood that alphabetic characters could be represented by a more complete code structure of this type.

The embodiments described below are directed to a receiving apparatus for installation at the called telephone site for decoding such a series of transmitted pulse trains and for displaying the calling telephone number (and perhaps alphabetic information such as the caller's name) in either permanent or temporary form. In this manner, if the called telephone is engaged, the user can be notified of another party's attempt to call and of the calling party's identification in the form of the calling telephone number as well as possible extra code digits providing extra information about the calling telephone. Of course, such a receiver could also be used to provide this information to a non-engaged called telephone thus giving the called party some advance information about the calling party even before the called telephone is answered. In general the transmitting apparatus at the originating telephone exchange is stimulated to send the coded pulses upon receipt of (and between) either ring back signals or engaged signals.

It will be appreciated that embodiments of this invention could be used for receiving other forms of data as well. That is, the pulse trains received upon calling, for example, a bank could represent the caller's bank balance. Also, stock market quotations and many other types of information could be represented by the received pulse trains.

The possible uses of such a receiver to provide telephone call back information and to permit discretionary answering of the telephone, etc., should also be readily apparent. In addition, it is possible to utilize the receiver as an automatic call tracing apparatus in situations involving crimes such as extortion, threats and obscene telephone calls which are becoming more of a problem as telephones are ever more widely disseminated. Other uses will be apparent to those in the art.

Briefly, one embodiment of this invention comprises means for separating each incoming series of pulse trains into individual pulse trains which are then successively channelled to individual digit decoding and display means whereby each successive pulse train is individually decoded and displayed in decimal notation until the entire telephone number represented by the series of pulse trains is available for the called telephone user's information. Other embodiments utilize a printing apparatus for printing each digit of information as it is received or shortly thereafter to permit use of any desired number of digits in any given transmission.

In one of the exemplary embodiments described in more detail below, the pulse trains are separated and decoded by electronic means including a logic gate for passing each individual pulse train to an associated decoding and display apparatus. Each logic gate is contolled by a particular stage of a shift register means which is, in turn, controlled by electronic means for detecting the extra dead time space occurring between pulse trains and by a special means for detecting the uniquely identifiable or starting pulse train. In effect, the starting pulse train synchronizes the receiving apparatus with the transmitted pulses by initiating the shift register's operation in a predetermined state corresponding to the beginning of a complete series of pulse trains. Thereafter, each detected extra dead time space between pulse trains causes the shift register to shift and thereby enable the next successive gate for passing the next pulse train to the next successive digit decoding and display stage.

Another embodiment of the invention uses a single printing stage for both decoding and printing each individual successive digit of the incoming data. Once a uniquely identifiable start signal or digit is detected, subsequent pulse trains cause a print wheel to be incrementally advanced by each incoming pulse with printing occurring in a space between each pulse train which is detected by a digit separation detector. Preferably, to increase the efficiency and simplicity of the decoding and printing mechanism, the incoming pulse trains are coded such that each pulse train includes the requisite number of pulses for advancing a print wheel to the desired position. Thus, in this embodiment, the number of pulses in a given train representing a given digit value is a function of the previous digit values in that particular data transmission.

Reference will now be made by way of example to the accompanying drawings in which:—

Figure 1 is an overall block diagram of one embodiment of the invention,

Figure 2 is a more detailed circuit diagram of a typical pulse amplifier and shaper and digit separation detector for use in the corresponding block position shown in Figure 1,

Figure 3 is a more detailed circuit diagram of a typical start signal detector for use in the corresponding block position shown in Figure 1,

Figure 4 is a more detailed circuit diagram of a typical modified shift register for use in the corresponding block position shown in Figure 1,

Figure 5 is a more detailed circuit diagram of a typical decoding and display means for use in the corresponding block position shown in Figure 1,

Figure 6 is a graph showing some of the wave forms occurring in the exemplary embodiment of Figure 1,

Figure 7 is a block diagram of another embodiment of the invention,

Figure 8 is a more detailed cross-section view of a printing mechanism for use in the embodiment shown in Figure 7,

Figure 9 is a front view of the mechanism shown in Figure 8,

Figures 10 and 11 are cross-section views of part of the mechanism shown in Figure 8,

Figure 12 is a block diagram of a further embodiment representing a modification of the embodiment shown in Figure 7, and

Figure 13 is a more detailed cross-section view of a printing mechanism for use in the embodiment shown in Figure 12,

Referring to the drawings, the embodiments now to be described exemplify the features recited in the appendant claims 1 to 18.

Referring to Figure 1, a receiver input on line 10 is taken from the incoming telephone line and, after amplification and shaping is presented on lines 12 and 14 as a series of pulse trains such as partially shown on line *a* of Figure 6. Here the first or starting train comprises twelve adjacent pulses while the next two pulse trains comprise five and one pulses respectively.

These pulse trains are all input via line 16 to one input of gates G1, G2 . . . G12. Thus, when the other input of these gates is operative (by a low input in the case of NOR gates, as shown), the pulse train occurring during the period of operation will pass on to the respectively associated decoding and counting units DCU #1, DCU #2... DCU #12 as should be apparent from Figure 1. That is, to function properly, gate G1 should be operative during the time when the pulse train of five pulses is present on line 16 while gate G2 should be operative for the next pulse train of one pulse, etc. In this manner, each digit of the calling telephone number is successively displayed after successive gating and decoding of each corresponding pulse train as should now be apparent.

To accomplish this result, the other input of each gate G1, G2 . . . G12 is controlled on lines 18, 20 . . . 40 coming from successive individual stages of a modified shift register 42. By properly controlling the shift register, a predetermined stage existing in any particular stage will operate the proper associated gate G1, G2 . . . G12 at the proper time.

The shift register 42, is, in turn, controlled by a start signal detector 44 and a digit separation detector 46. Before receipt of a series of pulse trains, the shift register is in a quiescent state with all stages in a common state that prevents passage of any pulses through gates G1, G2 . . . G12. Then, when the starting pulse train of, for instance, twelve pulses is detected by detector 44, a start flip-flop 48 is set and that, in turn, causes the first stage of register 42 to change state thus setting gate G1 as shown on lines *b* and *d* of Figure 6. Thereafter, the register 42 is caused to shift by detecting digit or pulse train separations signified by negative transitions of the output from detector 46 as indicated by the arrows on line *c* of Figure 6.

Accordingly, gate G1 remains "on" for the duration of the first pulse train. Then, gate G1 turns "off" and gate G2 turns "on" until the end of the second pulse train is detected, etc. After the last stage of register 42 has set gate G12, an end signal on line 50 flips a monostable delay circuit which disables start flip-flop 48 for a predetermined time period thus preventing another decoding cycle from beginning until the just displayed information has been available to the called telephone user for the predetermined time period.

As shown in Figure 1, 12 channels are provided to accommodate 2 added information digits in addition to the standard 10 digit telephone number (including an area code). Of course, any desired number of digits can be accommodated by adding or subtracting shift register stages and associated gates, decoding and display apparatus.

Referring now to the exemplary pulse amplifier and shaper and the digit separation detector shown in Figure 2, the input circuit is an emitter-follower amplifier or switch which serves to amplify the input current. Its output is connected to an integrated circuit Schmitt trigger, which is utilized to square the input pulses as should be apparent to those in the art. The Schmitt trigger includes two typical two-input gates (for example Motorola MC724P). The output of the emitter follower switch is also connected with the input of a one-shot multivibrator

comprising the digit separation detector as shown in Figure 2.

The input means could just as well comprise conventional automatic gain or level control circuitry and/or clipping circuits to standardize the input pulses.

The one-shot multivibrator unit provides an output at the end of each digit of the incoming calling number by utilizing the knowledge that between each two of the incoming trains of pulses, there is a dead time equal to at least two periods at the receiving frequency. As soon as the first positive pulse of a train of pulses representing a digit appears in the input of the one-shot, its output will become positive as shown on line *c* of Figure 6. During the half negative period of the input pulse, the output of the one-shot will remain positive because the time constant of R1 C1 and hence the period of the one-shot has been made at least equal to one period at the incoming frequency.

As the last pulse of the one-shot input pulse train changes to zero volts, the output of the one-shot will also drop to zero volts after a time equal to the time constant R1 C1 and will remain at zero level until the first positive pulse of the next train of pulses occurs representing the next incoming digit. Thus, as shown on line *c* of Figure 6, each negative transition of the digit detector output represents a point in time that occurs between individual incoming pulse trains.

Referring now to Figure 3, a typical start signal detector circuit is shown in more detail. In essence, this circuit comprises two digital counters with one counting clock pulses (occurring at the same nominal frequency as pulses within a pulse train) and another counting incoming pulses. If, during a single pulse train, both the counters reach a predetermined contents, such as eleven, then this is an indication that that particular pulse train has at least eleven pulses. Actually, since in the exemplary embodiment shown, the first pulse of a train is utilized to set the input gating circuits, when the counters reach eleven, it indicates that a total of twelve pulses have occurred in the same pulse train. Since only the uniquely identifiable "starting" pulse train has twelve pulses, the coincidence of a contents of eleven in both of the counters is taken as an indication of the starting pulse train and a complete operational cycle of decoding and displaying a complete series of pulse trains is initiated.

Referring to Figure 3, the first counter comprises four flip-flops FA—FB—FC—FD, forming a binary counter. The second counter also comprises four flip-flops FK—FL—FM—FN forming another binary counter. Gate 80 will feed clock pulses to the first binary counter and after eleven pulses this binary counter will be in a configuration of: FA "ON", FB "ON", FC "OFF", and FD "ON" as should be apparent to those skilled in the art. Gate 82 feeds the second binary counter with pulses coming from the telephone line. If these pulses are the predetermined uniquely identifiable signal, then at the end of the eleventh pulse, the second binary counter will also be in the same configuration as the first one. That is: FK "ON", FI "ON", FM "OFF", and FN "ON". As soon as the first binary counter is placed in the said configuration, the output of gate 84 will be placed in a plus (+) potential condition and with the next rise of a clock pulse, flip-flop 85 will be flipped thus causing buffer 86 to give a positive pulse to reset both counters and to trigger start flip-flop 48.

Due to the configuration of the second binary counter, gate 88 will make the input S of flip-flop 48 (Starting flip-flop) positive, and inverter 90 makes the input C of FS ground (zero volts).

Then when the buffer 86 provides a positive pulse on line 92 the following things take place (assuming receipt of the uniquely identifiable signal):

a) Flip-flop 48 turns "ON" (i.e. Q outputs plus (+) potential and $\overline{Q}$ '0' potential).

b) Buffer 94 gives a positive pulse which is used to reset the Flip-flops FF2 to FF12 and DCU #1 to DUC #12.

c) Both binary counters will be reset.

Flip-flop 96 is to control the gates 80 and 82 properly. For instance; suppose that when monostable 52 has gone off, then the first pulse of the predetermined signal of 12 pulses appears in the input of the circuit, flip-flop 96 will be flipped "ON" and latched in that condition until reset by a pulse from buffer 86. The output $\overline{Q}$ of flip-flop 96 will then become "zero" volts thus enabling gates 80 and 82. As can be seen, this gate setting process has consumed the first pulse so that the actual counter contents is one less than the number of pulses in the pulse train as previously noted.

On the other hand, suppose the first pulse train which comes from the telephone line is not the predetermined signal. In this case the counters will begin to cycle, but the moment that the first binary counter reaches the predetermined configuration of FA "ON", FB "ON", FC "OFF", and FD "ON", the second binary counter will not then be in the same configuration, because the incoming pulse train will not have twelve pulses.

Since the first binary counter always reaches the predetermined configuration, buffer 86 always provides a positive pulse which appears in the T input of flip-flop 48. But since the second binary counter will be in a configuration different to the desirable one (the desirable one being: FK "ON", FL "ON", FM "OFF", and FN "ON"), flip-flop 48 will

not change states but rather, the input S of flip-flop 48 will still be zero volts and input C of 48 will be positive and so flip-flop 48 will remain "OFF". However, as should be apparent, buffer 86 will still reset both binary counters to prevent the next pulse train pulses from accumulating in the second counter.

Reference is now made to the exemplary embodiment of the modified shift register or priority determining unit shown in more detail at Figure 4. This unit comprises a number of flip-flops corresponding to the number of digits needed to record the calling telephone number and any added information digits. Each one of flip-flops FF1, FF2, FF3 . . . FF12 is connected to a gate G1, G2, G3 . . . G12, and each gate is connected with one decade counter unit (DCU #1, DCU #2 . . . DCU #12) as previous described.

Now, as shown in Figure 4, as soon as starting flip-flop 48 turns "on", a trigger is given to the first flip-flop FF1 of the priority determining unit or shift register. Thus, FF1 will turn "on", causing its Q output to turn positive and the $\overline{Q}$ to turn to zero volts. The output $\overline{Q}$ is then connected to one leg of the G1 gate and so this gate is set or prepared to permit the first train of pulses, representing the first digit of the calling number, to pass therethrough and to appear at the input of the first decade counter unit DCU #1. At the end of this train of pulses the output of the one-shot or digit separation detector 46 will drop to zero volts, and this negative transition will give a trigger to all the rest of the flip-flops FF2, FF3 . . . FF12 of the shift register, but only FF2 will turn "on" at this time, because only the previous FF1 is "on".

As soon as FF2 turns "on", FF1 turns "off" because the Q output of FF2 turns positive and is used to reset FF1 as shown. The $\overline{Q}$ output of FF2 turns to zero volts as should be apparent. Accordingly, the $\overline{Q}$ output of FF2 is connected with one leg of gate G2 to set this gate for passing the second train of pulses representing the second digit of the calling number which will appear at the input of the second DCU #2. At the end of this train of pulses the one-shot or detector 46 will give another trigger to all flip-flops (except FF1) of the shift register 42. This trigger will turn "on" and turn "off" FF2, etc.

After having permitted the appearance of the last digit in the DCU #12 (i.e., FF12 is "on"), the one-shot detector 46 will give a final trigger to the shift register stages FF2 to FF12. This trigger will turn off FF12 and provide an input signal to a monostable multivibrator 52, which with a delay determined by an RC circuit, resets the start flip-flop 48, and keeps it blocked for a certain predetermined time during which no further pulse trains may be decoded such that the just decoded and displayed calling telephone number will not be disturbed for at least this predetermined delay period.

The decade counter unit DCU #1 is shown in more detail at Figure 5. In essence, it may comprise any suitable (e.g. conventional) digital counting and display mechanism. In the preferred exemplary embodiment shown in Figure 5, a solid state binary counter is connected to count one decimal decade and to provide corresponding electrical outputs on a decade of output lines as shown. These electrical output lines are then connected to any suitable decade display device as will be appreciated by those in the art. Of course, electro-mechanical decoding and/or display and printing apparatus could also be used as should be apparent. Also, of course, any suitable digital display system that may be developed in the future can be used for the DCU devices.

A further exemplary embodiment of this invention is shown in block diagram form in Figure 7. Here, the pulse shaper and amplifier 11, the digit separation detector 46, the start signal detector 44 and flip-flop 48 all function exactly as previously explained. However, now, rather than route each successive pulse train into a separate decoding and display channel, all the trains are processed in sequence by a single channel with each train being individually decoded and recorded.

A rotatable printing wheel with twelve circumferentially spaced print faces is utilized in this exemplary embodiment. For instance, the first ten faces would have the decimal digits 1, 2, 3, 4 . . . 9, 0 embossed in bas-relief thereon while the eleventh face might have the letter E embossed thereon and the twelfth face would have no figure, i.e. a blank that produces no print character.

In a normal rest state, the print wheel is aligned with the blank face opposite a print station wherein paper or other recording medium is moved by electromagnet 100 towards the print wheel to receive a print impression therefrom. In the rest condition any negative transitions from digit separation detector 100 would not result in any actual printing since the blank print face is located opposite the print station.

However, as soon as start flip-flop 48 is set by start signal detector 44, then AND gate 102 is set by a signal on line 104 and thereafter incoming pulses on line 12 will be passed through to operate electromagnet 106 which causes the print wheel to rotate by 1/12 of a revolution for each received pulse. Thus, in the case of presumed incoming

pulse trains having 5, 8, 2, 4, 3, 5, 2, 2, 1, 11 pulses respectively, the wheel would first be rotated 5/12 of a revolution until the print face having numeral "5" thereon is opposite the print station. Thereafter, the dead time between the first and second pulse trains will result in a negative transition of the digit separation detector 46 which will cause printing of the digit "5" and subsequent advancement of the paper through the print station. Then, the next pulse train of eight pulses will rotate the print wheel an additional 8/12 revolution until the digit "1" is opposite the print station. Thereafter, digit separation detector 46 will cause printing of this digit. The same process will eventually result in the printed number 5137035787 as should now be apparent.

While this embodiment has the distinct advantage of being capable of handling an unlimited number of digits (i.e. an unlimited data receiving capacity), at the same time it should now be evident that it requires a slightly more complicated coding scheme at the transmitter. That is, except for the first pulse train, the number of pulses in each train must now corresponding to the incremental difference between the last print wheel position and the desired next print wheel position. Of course, the simpler coding scheme could still be used if the print wheel were always returned to the blank print position after each printing operation but this would add some further complication to the print wheel mechanism.

A more detailed view of some of the mechanical elements of this last embodiment is shown in Figures 8, 9, 10 and 11.

The coil of electromagnet 106 operates a ratchet arm 110 which, in turn, incrementally engages and advances a ratchet wheel 112 attached to the twelve sided print wheel 114 thus providing means for incrementally advancing the print wheel as will be apparent to those in the art. The twelve sided print wheel has the following bas-relief characters embossed on its faces: "1", "2", "3", "4", "5", "6", "7", "8", "9", "0", "E", " " (blank space). To achieve a 1/12 revolution for each cycle of the electromagnet 106, the ratchet wheel 112 has 12 cogs 116 and 12 holes 118. A spring biased slug 120 may be actuated by suitable means (an electromagnet) to fix any particular hole 118 and thereby hold the print wheel position fixed while ratchet arm 110 is being moved backwards in readiness for its next forward ratcheting motion. Thus, every time electromagnet 106 is energized it can be arranged to cause a 1/12 revolution of print wheel 114.

A paper (such as impact sensitive chemical paper or the like paper or other recording medium) web 122 is unwound from roll 124 over rollers 126, 128 through friction or pin hole drive wheels 130, 132 at least one of which is driven by some means such as the ratchet arm 134 and attached ratchet wheel 136 shown in Figure 8.

The paper is drawn over a time printing cylinder 138 and a character print station 140. On top of the time printing cylinder 138 are embossed time printing wheels which are turned through cog wheels by a clock motor 142 in the conventional manner. Thus, the current time (day, month, year, hour, minute, etc.) information may be recorded on the recording medium by bringing the printing cylinder 138 up to press the paper against inked time printing wheels 140.

At the same time, another conventional clock device 144 may also be driven by clock motor 142 such that the current time is shown through a viewing window 146.

In addition, the paper passes under print wheel 114 at print station 140. Every time electromagnet 100 is released (negative transition of digit separation detector 46), spring 148 causes lever arm 150 to rise. Thus, print station 140 is actuated by an upward movement of the right hand end of arm 150 while ratchet arm 134 rises up to catch another cog on wheel 136 such that after the print is completed and arm 150 lowers again (electromagnet 100 energized) ratchet arm 134 will cause rotation of feed rollers 130, 132 to result in a paper feeding motion in readiness for printing the next character. In addition, a small projection 152 from arm 150 also actuates the time printing cylinder in the conventional manner to cause printing of the time data.

After such printing, the paper strip is moved through a viewing chamber 154 with a light source 156 below the paper and projecting through a transparent window 158 so that both the recorded time and number are visible to a user. Of course, the paper may be advanced on through the receiver by turning wheel 160 manually and the paper may be torn therefrom for other uses. The window 158 may have a 45° prism corner for 90° offset viewing of the data if desired. As shown in Figure 10, both the wheel 114 and the timing wheels 140 are in contact with inked cylinders 162 and 164 respectively to keep the raised print characters covered with a film of ink in the conventional manner.

In operation, as soon as a pulse train of 12 pulses is received, the start signal detector 44 turns the start flip-flop "ON". The following pulses are passed by gate 102 to electromagnet 106. The electromagnet 106, in turn, causes the print wheel 114 to rotate 1/12 revolution for each received pulse. So if the first digit transmitted after the unique value "12" is the value "0", the pulse train will have ten pulses therein to cause wheel 114 to step around 10/12 revolution until the number "0" appears at the print point or station where the paper is opposite the

wheel. Now there is a dead time between the first and the second pulse trains and during this dead time, digit separation detector 46 will have a negative transition causing armature 150 of electromagnet 100 to move upward against the paper on the bas-reliefed inked surface, and by this movement, the number will be printed in the paper. In turn, the electromagnet 100 will again be energized and because of this, arm 150 will move down, ratchet arm 134 will turn the wheel 136 which will advance the paper 122 one step. At the same time, the time printing cog wheel 138 will advance one step.

Subsequently, the electromagnet 106 will be stimulated as soon as the second digit is received (i.e. the second pulse train) and if the second digit is different than the first one the electromagnet 106 will cause the necessary incremental rotations of wheel 114. But if this second digit is of the same value as the first (in this immediate example, the number "0") then the transmitter will not send any pulse and so the wheel 114 will remain unmoved for this time. Now after a certain time (equal to twelve clock pulses time) the digit separation detector is programmed to give another new pulse to the electromagnet 100 which, in turn, causes printing once more of the number "0" in the paper. Of course, the paper and the time printing cylinder 138 will also be advanced one step. If the next received digit value is the number (2) two, the transmitter will have been programmed to send four (4) pulses which is, of course, equal to the already programmed space existing on wheel 114 between the number "0" and number "2".

The two pulses have now been passed through the digit separation detector 46 orders the electromagnet 100 to print the number 2 on the paper as should now be apparent.

The time printing cylinder 138 carries an eccentric arm throughout its length which cam strikes against the paper and prints all the time elements that exist at an exact moment; however, this movement can take place only once per revolution when the surface of the cylinder is in such a position that it can press against the paper. Thus, since the cam is only incrementally advanced each time the paper is advanced, by adjusting the number of cogs on drive wheen 162, the time data can be caused to print at any desired interval. In the embodiment, the number of cogs on wheel 162 has been fixed at sixteen cogs, and this means that the time data is going to be printed after each sixteen cycles of the electromagnet 100. It can be programed to print the time data during the first or second or third cycle of the electromagnet 100.

Then in turn, if the next digit value that is to be received is the number one, then, the transmitter will be programmed to send eleven pulses, which is the exact distance between the numbers 2 and 1, on the wheel 144. After the eleven pulses have been received, the digit separation detector will order the electromagnet 100 to print and advance the paper. If the next digit is number 3 then the transmitter will have been programmed to give two pulses (equal to the distance between numbers 1 to 3 on wheel 114).

As mentioned before, the transmitter has been programmed to give the difference between each two different digit values each time on the wheel 114. That is to say, if it is desired to transmit the number

205 6 2528161 E442

the transmitter will transmit the following numbers of pulses in successive pulse trains: 12 (as starting signal), and then 2, 8, 7, 1, 8, 3, 9, 6, 5, 5, 7, 10, 5, 0, 10, 10.

The last train of pulses represents the distance between the last transmitted number and the blank or nonprinting position on wheel 114. This last train is added because the wheel 114 must be returned to the same exact starting position each time in order to be able to accept any new incoming calling number. Further, this will avoid anything else from being printed on the paper during all following cycles of electromagnet 100 until the next start signal is received and detected. In the embodiment, the electromagnet 100 will normally go through twenty cycles for each received telephone number. From these twenty stimulations the first sixteen are used for actually transmitting the telephone number and printing it on the paper (the first three are for the area code, the fourth one is for a special code, the seven following are for the telephone number, per se and the last four are for any extension number. All the remaining four cycles (or as many as desired) are used to remove the paper with the printed number thereon (and the simultaneously printed calling time) into the center of panel window 158. The number and time data are printed in the same area of the paper but in different levels as shown in Figure 9.

The bas-reliefed letter E, on the wheel 114 can also be transmitted in code by the transmitter, and after the letter E the following digits would represent any extension numbers. This would primarily be useful in application to large organizations, which use such telephone extension services as will be apparent. Of course, the transmission of such extra digits as extension numbers is facilitated in this embodiment since as many digits as desired may be transmitted without changing the receiver in any way. That is, this system has unlimited receiving capacity, which is different than the earlier described embodiments which have been prepared to accept a

limited (i.e. predetermined) number of digits.

The digit separation detector 46 in this last embodiment can be comprised of a switch in series with the coil of the electromagnet 100 instead of the monostable previously discussed. Here, the switch should be mechanically coupled to turn off when electromagnet 100 is stimulated and to turn on with disstimulation of the electromagnet 100. Since the switch action timing (and hence the stimulation-destimulation cycle of electromagnet 100) is a function of the mechanical linkage, the coil electrical characteristics and the supply voltage, the timing can be adjusted by adjusting these parameters to cause the cycling to correspond with receipt of complete pulse trains and therefore to result in operation similar to that already described.

Another embodiment is shown in block form at Figure 12. Actually this embodiment is just like that of Figure 7 except that a digital stepped motor 202 is used to turn a print wheel instead of the pawl and ratchet means of Figure 7. In this manner a higher frequency of received pulses may be accommodated. Since the conventional stepped motor used in the exemplary embodiment requires an associated electronic switch 204, this element is used instead of the simpler AND gate. Further, since the motor has 24 steps per revolution, the print wheel preferably has 24 faces whereby one rotation of the print wheel in this embodiment is equivalent to two rotations in the embodiment of Figure 7.

As shown in Figure 13, most of the elements are analogous to those of Figure 7 and use the same reference numerals. Only the stepped motor 202 and 24 sided print wheel 204 are different in principle. Since stepped motors and their operation are already well known in the art, no detailed explanation of the operation of the Figure 13 elements is believed necessary. It should be apparent from that already given for Figures 7 to 11.

Although not shown in the drawings, if a still higher receiving rate were desired, it could be accomplished by adapting another stepped motor to substitute for the electromagnet 100. Another electronic switch would have to be connected between the digit separation detector 46 and the new stepped motor.

All of the above described embodiments could be enhanced by adding memory units. For instance, if buffer memory units were used at the input of the embodiments described with reference to Figures 7 to 13 to temporarily store the incoming data, the incoming information could be rapidly stored therein and later read out at a slower rate to permit printing at a later desired time. In this manner, the memory would act as an effective delay unit to accommodate the relatively slow speed mechanical or other printing elements. The memory could also function as a storage unit of any desired capacity to hold data therein for subsequent printing upon demand.

A memory unit could also be used with the electronic receiver of Figure 1 as a method of increasing its capacity for holding and displaying data. Also, a plurality of storage units could be used in data checking operations to insure accurate received data before display. For instance, two identical sets of pulse trains could be transmitted at different times. If the decoded (or coded) received data is stored away for each set of pulse trains, it may be compared before a display or recording thereof is effected only if the two sets are equal.

It should also be noted that the embodiment of Figure 1 can easily be modified to decode the pulses transmitted as necessary in the embodiments of Figures 7 to 13. For instance, if all gates G1—G12 are initially opened for the first pulse train, then only gates G2—G12 are opened for the second pulse train, then only gates G3—G12 are opened for the third pulse train, etc. and if DCU #1—DCU #12 carried on the twelfth count rather than the tenth (i.e. no longer *decimal* counters), then it follows that the proper result would be displayed in the various channels as may be verified by a straight forward analysis. Further, this conversion would be very simple since, in addition to the already discussed modification of DCU #1—DCU #12, all that needs to be done is to move the connections from $\bar{Q}$ (to gates G1—G12) to Q on FF-1 to FF-12 and to eliminate the interstage reset feedback between the bistable stages FF-1 to FF-12. In this manner, the gates G1—G12 would be controlled as previously discussed.

Of course, the newer solid state printers, and so forth, may also be used in embodiments of this invention as should be apparent to those skilled in the art.

Further, an appropriate oscillator could be incorporated in a receiver embodiment of this invention for stimulating a busy or ring back tone to the local exchange thus stimulating the local exchange transmitter to transmit the number just dialed right back to the calling telephone so that the caller can observe the correctness of the number just dialed if this feature is desired.

WHAT I CLAIM IS:—

1. Apparatus for decoding a plurality of signal pulse trains, each pulse train representing one digit or other character of information data, and for displaying the data, the apparatus comprising input means for accepting the signal pulse trains, digit separation detector means connected to the input means for discriminating between individual pulse trains and for generating a digit separa-

tion signal in response thereto, starting detector means connected to the input means for detecting a pulse train different from said individual pulse trains and for providing a start signal in response thereto, decoding and display means connected to the digit separation detector means and to the starting detector means for decoding each of said individual pulse trains received and displaying a corresponding character, after the said different pulse train has been detected.

2. Apparatus as claimed in claim 1, wherein the decoding and display means comprises a rotatable print wheel, incremental drive means connected to the print wheel, to the starting detector means and to the input means for incrementally rotating the print wheel in response to each pulse of incoming said individual pulse trains occurring after detection of the said different pulse train, and means connected to the digit separation detector for recording characters on a recording medium from the print wheel in response to the digit separation signal.

3. Apparatus as claimed in claim 2, wherein the incremental drive means comprises an electromagnetically actuated pawl and ratchet assembly.

4. Apparatus as claimed in claim 2, wherein the incremental drive means comprises a digital stepped motor.

5. Apparatus as claimed in any preceding claim, comprising recording medium advancement means for automatically advancing a recording medium in cooperation with the means for recording characters.

6. Apparatus as claimed in any preceding claim, comprising recording means for automatically recording current time data together with the information data on a recording medium.

7. Apparatus as claimed in any preceding claim, wherein the display means includes recording means for effecting a potentially permanent display of the information data.

8. Apparatus as claimed in claim 1, or any one of claims 5 to 7 when not appendant to claim 2, wherein the decoding and display means comprises a plurality of separate channels for individually decoding and displaying each pulse train representing one character of the information data, and separation means for effectively separating and directing each successive pulse train to a particular corresponding channel for individual decoding and display.

9. Apparatus for decoding a plurality of signal pulse trains, each pulse train representing one digit of a number and for displaying the number, the apparatus comprising digit detector means for discriminating between individual pulse trains and for generating a digit separation signal in response thereto, starting detector means for detecting a pulse train different from said individual pulse trains and for providing a start signal in response thereto, shift register means comprising a plurality of interconnected bistable stages, the shift register means being connected to the digit detector means and to the starting detector means to cause successive ones of the bistable stages to change state in response to successive digit separation signals occurring after the start signal, a plurality of gate means each having one input connected to one of the bistable stages and another input connected for receiving the signal pulse trains whereby any given gate means is enabled to pass the next occurring pulse train in response to its associated bistable stage changing state, and counting and display means connected to each gate means for decoding and displaying the particular pulse train passed by its associated gate means whereby successively to decode and display each successive digit of the number.

10. Apparatus as claimed in claim 9, wherein the digit detector means comprises a monostable multivibrator arranged to make use of having a period at least equal to an intended time period between successive pulses of a single said individual pulse train.

11. Apparatus as claimed in claim 9 or 10, wherein the starting detector means comprises clock means for generating clock pulses, first counter means, second counter means, gating means for simultaneously gating clock pulses to the first counter means and the signal pulses to the second counter means, first decoding means connected to the first counter means for detecting a predetermined contents thereof and for generating a first signal in response thereto, second decoding means connected to the second counter means for detecting a predetermined contents thereof and for generating a second signal in response thereto, and means connected to the first and second decoding means for generating the start signal in response to the simultaneous existence of the first and second signals whereby the start signal signifies receipt of a signal pulse train having a predetermined number of pulses.

12. Apparatus as claimed in claim 9, 10 or 11, wherein the shift register means comprises a plurality of cascaded bistable flip-flop stages with a first stage connected to the starting detector means and with all other stages connected to the digit detector means.

13. Apparatus as claimed in claim 9, 10, 11 or 12, wherein each of the gate means comprises a logical NOR gate.

14. Apparatus as claimed in any one of claims 9 to 13, wherein each of the counting and display means comprises digital decimal counting means for counting the number of pulses in a given pulse train and for providing electrical outputs representing the number of counted pulses, and visible display means for recording the electrical outputs

as a decimal representation thereof whereby each digit of the number is recorded in a decimal notation.

15. Apparatus as claimed in any one of claims 9 to 14, further comprising delay means connected to the last one of the bi-stable stages for detecting the last of the series of pulse trains representing the number and for automatically disabling the shift register means for beginning another cycle of operation for a predetermined time period whereby continuous display of the entire number is insured for at least the predetermined time period.

16. Apparatus as claimed in any one of claims 9 to 15, further comprising input means connected for receiving the signal pulse train and for amplifying and shaping the individual pulses thereof before subsequent use in the apparatus.

17. Apparatus as claimed in claim 16, wherein the input means comprises solid state amplifier means for amplifying the pulses, and trigger means connected to the amplifying means for making the pulses of more uniform dimensions.

18. Apparatus as claimed in claim 17, wherein the trigger means comprises a Schmitt trigger.

19. Decoding and display apparatus substantially as described with reference to, and substantially as illustrated in, Figures 1 to 6, 7 to 11 or 7 to 11 as modified by Figures 12 and 13 of the accompanying drawings.

20. Decoding and display apparatus substantially according to any embodiment hereinbefore described with reference to the accompanying drawings.

21. A telecommunication system operatively including apparatus as claimed in any preceding claim.

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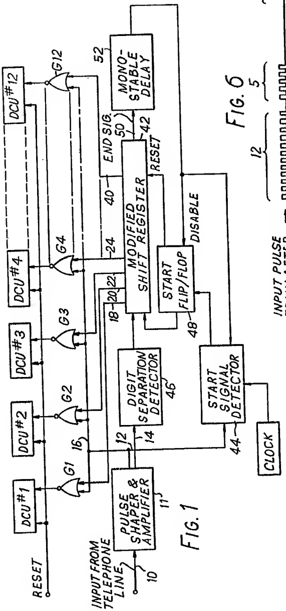

DCU #1
DCU #2
DCU #3
DCU #4
DCU #12
G1
G2
G3
G4
G12
RESET
INPUT FROM TELEPHONE LINE
10
PULSE SHAPER & AMPLIFIER
11
12
14
16
DIGIT SEPARATION DETECTOR
46
START SIGNAL DETECTOR
44
CLOCK
18
20
22
24
MODIFIED SHIFT REGISTER
40
END SIG.
50
42
RESET
START FLIP/FLOP
48
DISABLE
MONO-STABLE DELAY
52

FIG. 1

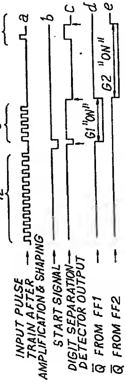

INPUT PULSE TRAIN AFTER AMPLIFICATION & SHAPING
START SIGNAL
DIGIT SEPARATION DETECTOR OUTPUT
Q̄ FROM FF1
Q̄ FROM FF2
12
5
1
a
b
c
d
e
G1 "ON"
G2 "ON"

FIG. 6

FIG. 2

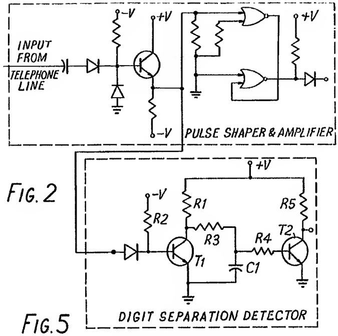
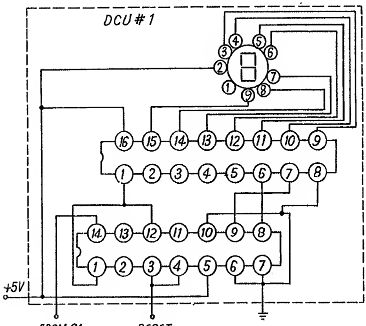

INPUT FROM TELEPHONE LINE
-V
+V
-V
+V
PULSE SHAPER & AMPLIFIER
+V
-V
R1
R2
R3
R4
R5
T1
T2
C1
DIGIT SEPARATION DETECTOR

FIG. 5


DCU # 1
+5V
FROM G1
RESET

7 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 3

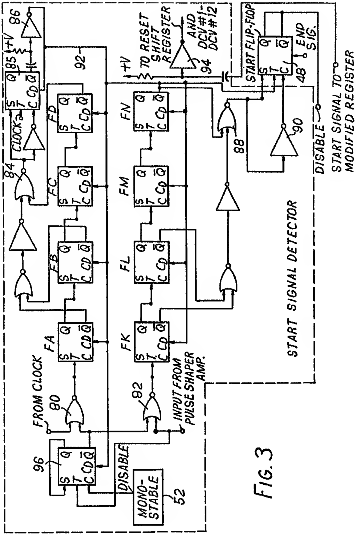


FIG. 3

7 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 4

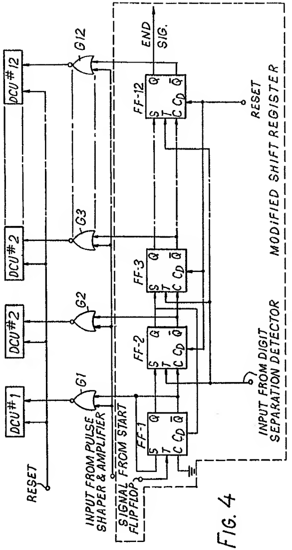


FIG. 4

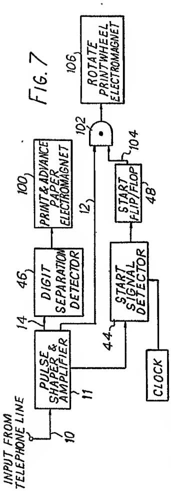

106
ROTATE PRINTWHEEL ELECTROMAGNET
102
104
100
PRINT & ADVANCE PAPER ELECTROMAGNET
12
START FLIP/FLOP
48
46
DIGIT SEPARATION DETECTOR
START SIGNAL DETECTOR
14
44
PULSE SHAPER & AMPLIFIER
11
CLOCK
INPUT FROM TELEPHONE LINE
10

FIG. 7

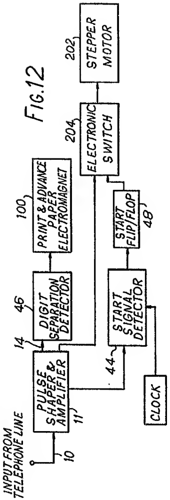

202
STEPPER MOTOR
204
ELECTRONIC SWITCH
100
PRINT & ADVANCE PAPER ELECTROMAGNET
START FLIP/FLOP
48
46
DIGIT SEPARATION DETECTOR
START SIGNAL DETECTOR
14
44
PULSE SHAPER & AMPLIFIER
11
CLOCK
INPUT FROM TELEPHONE LINE
10

FIG. 12

FIG. 8

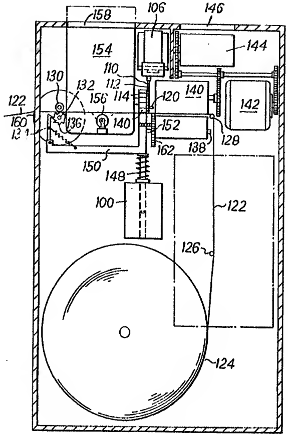
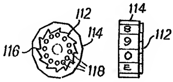

158
106
146
144
154
110
130
112
132
140
156
114
120
122
142
160
136
140
152
128
162
138
150
148
100
122
126
124

FIG. 11


112
114
114
112
116
118
8
9
0
E

7 SHEETS — This drawing is a reproduction of the Original on a reduced scale

Sheet 7

FIG. 9

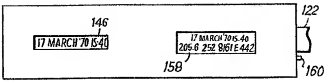


FIG. 10

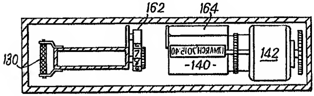


FIG. 13